accuracy is best exhibited by working out the actual value given by the formula for various angles. The subjoined table shows that the angles given by the formula are too large, though the error scarcely exceeds .01 of a degree, up to about 33°; that thereafter the results are too small, and after the angle exceeds 45°, the discrepancy becomes rapidly larger. Since we can always use the formula to compute an angle less than 45°, this later divergence does not affect its usefulness.

True Value.	Value by Formula.	True Value.	Value by Formula.
5°	5.0033	30°	30.0067
10°	10.0065	35°	34.9945
15°	15.0094	40°	39.9703
20°	20.0115	45°	44.9270
25°	25.0112	50°	49.8562

RECENT PUBLICATIONS.

REVIEWS.

General Theory of Polyconic Projections. By OSCAR S. ADAMS, Geodetic Computer. Published by the Department of Commerce, U. S. Coast and Geodetic Survey, Serial No. 110, Special Publication No. 57, Washington, D. C., 1919. 174 pages. Price 25 cents.

To quote from the author's preface, "In this publication an attempt has been made to gather into one volume all of the investigations that apply to the system of polyconic projections." The author gives[1] Tissot's definition of a polyconic projection as "one in which the parallels of latitude are represented by arcs of a non-concentric system of circles with the centers of these various circles lying upon a straight line." Polyconic projections of the sphere and the ellipsoid of revolution only are considered, the whole purpose of the work being the construction of maps of the surface of the earth either as a whole or in part. The table of contents has thirty-one headings: Determination of ellipsoidal expressions, Development of general formulas for polyconic projections, Classification of polyconic projections, Rectangular polyconic projections, Stereographic meridian projection, Derivation of stereographic meridian projection by functions of a complex variable, Construction of stereographic meridian projection, Table for stereographic meridian projection, Stereographic horizon projection, Derivation of stereographic horizon projection by functions of a complex variab e, Proof that circles project into circles in stereographic projections, Construction of stereographic horizon projection, Solution of problems in stereographic projections, Conformal polyconic projections, Determination of the conformal projection in which the meridians and parallels are represented by circular arcs, Special cases of the projection, General study of double circular projections,

[1] Page 10.

Conformal double circular projections, Cayley's principle, Discussion of the magnification on the conformal double circular projection, Equivalent, or equal area, polyconic projections, Conventional polyconic projections, non-rectangular double circular projections, Projection of Nicolosi or globular projection, Projection of P. Fournier, Ordinary or American polyconic projection, Tissot's indicatrix, Tables of elements of the ordinary, or American polyconic projection, Transverse polyconic projection, Projection for the international map on the scale of 1 : 1 000 000, Tables for the projection of the sheets of the international map of the world.

The book contains forty-eight figures and a folded frontispiece giving a transverse polyconic projection of the North Pacific Ocean.

The author states in the preface that in the preparation of the volume the following works were especially consulted: M. A. Tissot, *Mémoire sur la Représentation des Surfaces et les Projections des Cartes Géographiques*, Paris, 1881; A. Germain, *Traité des Projections des Cartes Géographiques*, Paris, 1866(?); N. Herz, *Lehrbuch der Landkartenprojectionen*, Leipzig, 1885; W. W. Hendrickson, U. S. N., *Notes on Stereographic Projection.*

The work may be described on the whole as a careful and detailed discussion of all such representations of the earth's surface on a plane as come under the definition of polyconic projection which have been found useful in practical map making. In general it may be said that the purpose of the discussion of each projection considered is first to determine and prove properties of the map as a whole, second to derive formulas for the coördinates of the point in the plane map representing a point of the earth's surface of given latitude and longitude, third to determine the scale or magnification of the map at any point in the directions of the circles of latitude and longitude. Both geometrical and analytical methods are extensively used. Not much mathematical knowledge is required of the reader, indeed we suppose the book to be intended rather for the practical maker of maps than for the mathematician. The author says, in the preface "it is hoped that the treatment may be found complete enough to serve all practical purposes." The figures are good, the book is well printed and remarkably free from misprints; we have noticed but two: on page 18, line 8, for M read N, on page 156, line 10 from the bottom, for "about" read "by."

Two paragraphs we find of particular interest, the analytical discussion of rectangular polyconic projection, pages 13 to 18, and the determination by the use of the complex variable of the conformal projection in which both meridians and parallels are represented by circular arcs, pages 80 to 86, presumably after Lagrange.

Considered as a mathematical treatise the book has some faults. There is an almost total lack of exact references, except to the author's earlier publication, *General Theory of Lambert Conformal Projection*, Special Publication No. 53, U. S. Coast and Geodetic Survey. It would add greatly to the interest of the work to give the names of the originators of the various projections with dates and exact references. A more serious fault is the nearly complete absence of any

attempt to explain the special advantages of the different projections or the particular purposes for which they were devised. We find rarely even so little of this kind of information as is contained in the following statements: "This projection has been much used by the English War Office for the construction of maps,"[1] or "The projection seems to have been devised by Supt. F. R. Hassler to meet the requirements in the charting of the coast of the United States."[2] It would be of interest to know what projections, proofs and discussions are original with the author.

We find the treatment uneven. Certain quite elementary problems, such as finding the integral, $\int \sec x\, dx$, are solved with wholly unnecessary detail, not once but several times, while other questions are handled sometimes without proper mathematical rigor and sometimes in an awkward way; some of the more technical map work lacks clearness. Thus the proof that in stereographic projection any circle of the sphere becomes a circle in the plane covers three pages[3] and is not very easy to follow. With the well-known formulas for the projection the proof may be given in a few lines. In the applications of the complex variable to the derivation of stereographic meridian projection and to stereographic horizon projection[4] the necessary functions, which are not very simple, are given and proved correct. It would be more natural to derive these functions by forming $x + iy$ from the known x and y, a procedure which must, we think, be that actually followed. In the presentation of Lagrange's work on the determination of the conformal projection in which the meridians and parallels are represented by circular arcs an unknown constant is taken[5] as β^2, and β is treated as real. There is no reason that the constant should be positive. In fact if β^2 is replaced by $-\beta^2$ the only effect is to interchange the λ and σ in the discussion. We have noticed one more serious omission: in the treatment of conformal polyconic projections[6] it is shown that the expression

$$u^2 \frac{u \dfrac{d\rho}{d\varphi} - \rho \dfrac{du}{d\varphi}}{u \dfrac{d\rho}{d\varphi} + \rho \dfrac{du}{d\varphi}}$$

is constant and that by a change of variable this expression is multiplied by an arbitrary constant. It is then stated that the expression may therefore be assumed equal to unity. The reasoning is correct unless

$$u \frac{d\rho}{d\varphi} - \rho \frac{du}{d\varphi} = 0.$$

[1] Page 18, referring to rectangular polyconic projection.
[2] Page 143, referring to American polyconic projection.
[3] Pages 43 to 46.
[4] Pages 30 and 42.
[5] Page 84.
[6] Pages 72 to 80.

By failing to consider this possibility one solution of the problem considered is lost, that is $s = \rho$, giving in the map circles of latitude passing through one point.

JAMES K. WHITTEMORE.

Lezioni di Calcolo Infinitesimale dettata nella R. Università di Bologna e redatte per uso degli studenti. S. PINCHERLE. Seconda edizione riveduta. Bologna, N. Zanichelli, 1920. 8vo. 8 + 785 pp. Price 40 lire.

Translation of an extract from the "avvertenza alla seconda edizione": "The lectures on the infinitesimal calculus which I gave to the press at the end of 1915, not without fear and trembling, have won favor, beyond all expectations, with the mathematical public, so that the call for a new edition came too soon to permit those modifications and additions that I had in mind to introduce.

"The second edition differs from the first only by slight changes, and only those parts have been retouched in which greater clarity or precision of statement seemed to me necessary."

Contents—Introduction, 1–50; Section first: Differential calculus, 51–302; Section second: Integral calculus, 303–484; Section third: Geometrical applications of infinitesimal calculus, 485–630; Section fourth: Differential equations, 631–764. There is a 14-page alphabetical index.

Leçons de Géométrie Supérieure. Par E. VESSIOT. Edition revue et augmentée. Avec une préface de M. G. Koenigs. Paris, J. Hermann, 1919. 10 + 376 pp. Price 30 francs.

Preface by E. Vessiot: "La première édition de ces leçons autographiée [1906], ayant été rapidement épuisée, j'ai accepté l'offre de réimpression que m'a faite M. Hermann. Les fautes d'impression avaient été corrigées par M. Anzemberger en vue de cette réédition. J'ai revu et amélioré la rédaction; et j'y ai fait des additions importantes. . . ."

Contents—I: Révision des points essentiels de la théorie des courbes gauches et des surfaces développables, 1–18; II: Surfaces, 19–34; III: Etude des éléments fondamentaux des courbes d'une surface, 35–60; IV: Les six invariants, La courbure totale, 61–81; V: Surfaces réglées, 82–120; VI: Congruences de droites, 121–160; VII: Congruences de normales, 161–189; VIII: Les congruences de droites et les correspondances entre deux surfaces, 190–237; IX: Les complexes de droites et les équations aux dérivées partielles du premier ordre, 238–268; X: Complexes linéaires, 269–292; XI: Transformations de contact, Transformations dualistiques, Transformations de Sophus Lie, changeant les droites en sphères, 293–315; XII: Systèmes triple orthogonaux, 316–325; XIII: Congruences de sphères et systèmes cycliques, 326–354; Exercices, 355–371.

Physical Bases of Ballistic Table Computations. Ordnance Textbook. [By Professor A. A. BENNETT.] (War Department, Document 972). Washington, Government Printing Office, 1920. 4to. 17 pp.

This monograph constitutes Part I of the Introduction of New Ballistic Tables being prepared by the Ordnance Department.

Quotation from 'Prefatory Remarks': "These new tables for exterior ballistics . . . were designed and supervised by the author of this introduction. The circumstances demanding their construction will not be reviewed in this part, nor will any account be given here of their form and content, nor of the technique and special devices used in their computation. It is only the physical facts and theories upon which these tables are founded that will here be treated, and even the history of these theories will be left with little more than mention.

"The matter treated here is qualitative rather than quantitative. The methods of numerical integration used in computing the trajectories, while in themselves only methods of approximation, are capable of giving results with any preassigned degree of accuracy, and as used yield vastly more precise figures than justified by the physical data available or the physical assumptions employed. This precision is obtained, however, at no extravagant sacrifice of labor, and secures results which are conveniently regular. Less accurate methods hitherto in vogue are now insufficient. The total number of physical factors in the problems of exterior ballistics is practically infinite. The elimination of all but a few is justified only by careful quantitative